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ABSTRACT

Chemistry 30 is a twelfth-grade chemistry course for students in Alberta, Canada. This document is a final test for the course. Intended for administration during June 1985, it contains 56 multiple-choice questions and three written-response problems. Two-and-one-half hours are allowed for completing the test. No answer key is included since scoring is done by the province education department. (JN)

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GRADE 12 DIPLOMA EXAMINATION

Chemistry 30

June 1985

Alberta
EDUCATION

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GRADE 12 DIPLOMA EXAMINATION
CHEMISTRY 30

DESCRIPTION

Time: 2½ hours

Total possible marks: 70

This is a **CLOSED-BOOK** examination consisting of two parts:

PART A: 56 multiple-choice questions each with a value of 1 mark.

PART B: Three written-response questions for a total of 14 marks.

A chemistry data booklet is provided for your reference. Approved calculators may be used.

GENERAL INSTRUCTIONS

Fill in the information on the answer sheet as directed by the examiner.

For multiple-choice questions, read each carefully and decide which of the choices BEST completes the statement or answers the question. Locate that question number on the answer sheet and fill in the space that corresponds to your choice. USE AN HB PENCIL ONLY.

Example

This examination is for the subject area of

A. Chemistry
B. Biology
C. Physics
D. Mathematics

Answer Sheet

A	B	C	D
●	②	③	④

If you wish to change an answer, please erase your first mark completely.

For written-response questions, read each carefully, show all your calculations, and write your answer in the space provided in the examination booklet.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

DO NOT FOLD EITHER THE ANSWER SHEET OR THE EXAMINATION BOOKLET

The presiding examiner will collect the answer sheet and examination booklet for transmission to Alberta Education.

JUNE 1985

PART A

INSTRUCTIONS

There are 56 multiple-choice questions with a value of one mark each in this section of the examination. Use the separate answer sheet provided and follow the specific instructions given.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

WHEN YOU HAVE COMPLETED PART A, PROCEED DIRECTLY TO PART B

DO NOT TURN THE PAGE TO START THE EXAMINATION UNTIL TOLD TO DO SO BY THE PRESIDING EXAMINER.

1. The potential energy of a substance includes the

   A. momentum of its molecules
   B. energy of its chemical bonds
   C. vibrational energy of the nuclei
   D. rotating motion of its molecules

2. When ice at 0°C changes to water at 0°C there is an increase in

   A. kinetic energy only
   B. potential energy only
   C. both kinetic and potential energy
   D. kinetic energy but a decrease in potential energy

3. For the chemical reaction $H_{2(g)} + V_2O_{3(s)} \longrightarrow 2VO_{(s)} + H_2O_{(g)}$, the substance that has a standard enthalpy of formation equal to zero is

   A. $H_{2(g)}$
   B. $VO_{(s)}$
   C. $H_2O_{(g)}$
   D. $V_2O_{3(s)}$

4. A student burned carbon in excess oxygen and determined the heat of combustion to be -405.2 kJ/mol. The percentage error for this empirical value is

   A. 2.89%
   B. 2.97%
   C. 11.7%
   D. 26.7%

5. The energy change that would NOT be exothermic is the

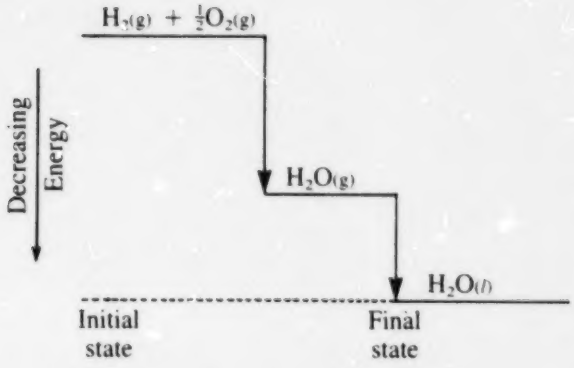
   A. freezing of water on a skating rink
   B. formation of snow from moisture in the air
   C. evaporation of water from the surface of a lake
   D. formation of rain droplets from water vapor in the air

6. If an exothermic reaction occurs in an insulated container, the temperature in the container will

   A. decrease
   B. increase
   C. remain constant
   D. be impossible to measure

7. A student produces water in the laboratory by burning hydrogen gas in air. The diagram that illustrates the total change in energy is

A.



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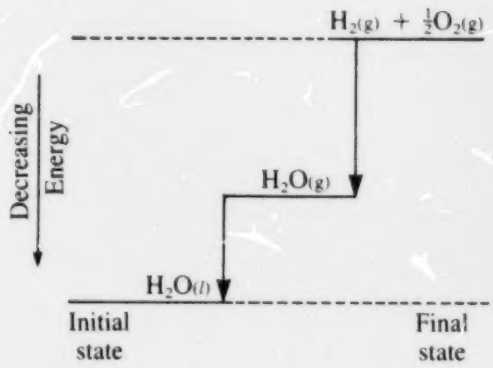

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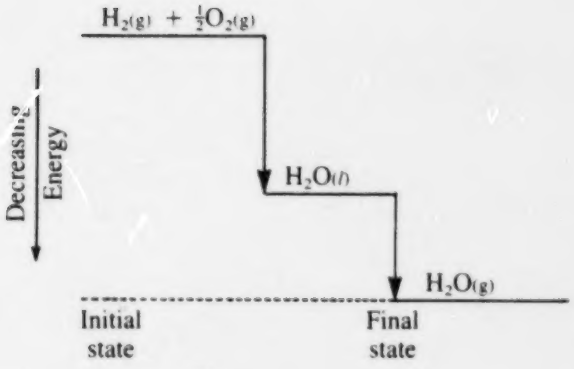
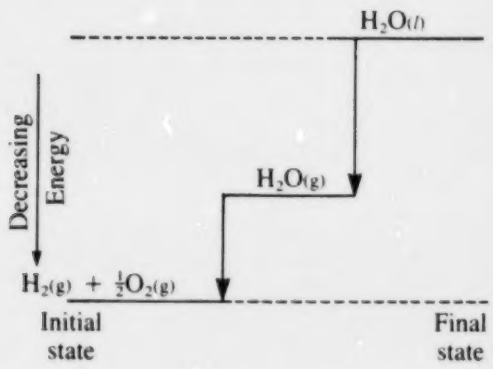


D.



8. The heat change associated with the burning of gasoline in a car is most likely to be

A. + 1000 kJ/mol
B. + 10 kJ/mol
C. − 1000 kJ/mol
D. − 1 000 000 kJ/mol

9. When steam at 100°C condenses, the energy released results mainly from the formation of

A. ionic bonds
B. covalent bonds
C. intermolecular bonds
D. bonds between nucleons

10. The heat of reaction for AB + XY ⟶ ABXY can be calculated using the formula

A. heat content of (AB + XY) + heat content of ABXY
B. heat content of (AB + XY) − heat content of ABXY
C. heat content of ABXY − heat content of (AB + XY)
D. heat content of AB + heat content of XY

11. The total heat released by the combustion of propane gas is primarily dependent upon the

A. temperature change
B. atmospheric pressure
C. moles of reactants involved
D. method of measuring the heat released

12. The burning of 12.0 g of urea, $CO(NH_2)_2$, raises the temperature of 1.00 L of water by 30.0°C. The heat released by the combustion of urea is

A. 1510 kJ/mol
B. 629 kJ/mol
C. 126 kJ/mol
D. 25.1 kJ/mol

Use the following information to answer question 13.

7.08 kJ of heat are required to raise the temperature of a calorimeter and its contents 1.0°C. When 0.90 g of ethane is ignited in a calorimeter, the temperature of the calorimeter and its contents rises 9.7°C.

13. The heat required for the combustion of ethane is

A. 6.2×10^1 kJ/mol
B. 1.4×10^3 kJ/mol
C. 2.1×10^3 kJ/mol
D. 2.3×10^3 kJ/mol

14. ΔH for the reaction $2KClO_{3(s)} \longrightarrow 2KCl_{(s)} + 3O_{2(g)}$ is

A. -44.7 kJ
B. -89.4 kJ
C. -871.8 kJ
D. -1654 kJ

Use the following information to answer question 15.

$$H_{2(l)} + L_{2(g)} + 62.85 \text{ kJ} \longrightarrow 2HL_{(g)}$$

$$H_{2(g)} + L_{2(g)} \longrightarrow 2HL_{(l)} + 29.33 \text{ kJ}$$

15. In the reaction $HL_{(l)} \longrightarrow HL_{(g)}$,

A. 92.18 kJ of heat energy are released per mole of $HL_{(g)}$
B. 46.09 kJ of heat energy are released per mole of $HL_{(g)}$
C. 92.18 kJ of heat energy are absorbed per mole of $HL_{(g)}$
D. 46.09 kJ of heat energy are absorbed per mole of $HL_{(g)}$

---

16. When 2.70 g of aluminum burns, 83.5 kJ of heat are released. This is consistent with

A. $4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)} + 1670$ kJ

B. $4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)} + 3340$ kJ

C. $4Al_{(s)} + 3O_{2(g)} + 3340 \text{ kJ} \longrightarrow 2Al_2O_{3(s)}$

D. $4Al_{(s)} + 3O_{2(g)} + 1670 \text{ kJ} \longrightarrow 2Al_2O_{3(s)}$

17. Consider the equation $6CH_3COOH_{(l)} + 11O_{2(g)} \longrightarrow 10CO_{2(g)} + 2CO_{(g)} + 12H_2O_{(l)}$. If 12.0 g of $CH_3COOH_{(l)}$ react, the heat released is

A. 155 kJ
B. 350 kJ
C. 778 kJ
D. 4660 kJ

Use the following information to answer question 18.

Assume that the amount of heat produced by the fusion of 2 mol of H atoms is 1.7×10^9 kJ.

18. The number of moles of $H_{2(g)}$ that must be burned to produce liquid water and this same amount of heat is

A. 6.0×10^{10} mol
B. 5.9×10^{6} mol
C. 1.7×10^{-7} mol
D. 2.0×10^{-9} mol

---

19. The hydrogen oxalate ion, $HOOCCOO^-$, is formed when oxalic acid is added to water. The resulting solution

A. tastes bitter
B. neutralizes acids
C. has a slippery feel
D. changes blue litmus to red

20. A neutralization reaction is represented by

A. $Ba^{2+}_{(aq)} + CrO_4^{2-}{}_{(aq)} \longrightarrow BaCrO_{4(s)}$

B. $2NO_3^-{}_{(aq)} + 4H^+_{(aq)} \longrightarrow 2H_2O_{(l)} + 2NO_{2(g)}$

C. $NaOH_{(aq)} + HClO_{4(aq)} \longrightarrow NaClO_{4(aq)} + H_2O_{(l)}$

D. $2CrO_4^{2-}{}_{(aq)} + 2H^+_{(aq)} \longrightarrow Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)}$

21. In an acidic solution, the concentration of the hydronium ions compared to the hydroxide ions is

A. 1.0×10^{-7} mol/L
B. the same
C. smaller
D. larger

22. Which of the following statements does NOT agree with the Brønsted-Lowry definition of acids and bases?

A. Water may act as an acid or as a base.
B. Acid-base reactions may involve the hydronium ion.
C. Acid-base reactions involve a transfer of hydrogen ions.
D. Acid-base reactions involve a transfer of hydroxide ions.

23. Consider the equation $H_2PO_4^-(aq) + CH_3COO^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + CH_3COOH(aq)$. The correct statement is:

A. $HPO_4^{2-}(aq)$ reacts as a base.
B. $CH_3COOH(aq)$ reacts as a base.
C. $CH_3COO^-(aq)$ reacts as an acid.
D. $H_2PO_4^-(aq)$ reacts as both an acid and a base.

24. When equal volumes of 0.10 mol/L $H_2PO_4^-(aq)$ and 0.10 mol/L $HSO_4^-(aq)$ are mixed, the base is

A. $H_3O^+(aq)$
B. $HSO_4^-(aq)$
C. $H_2PO_4^-(aq)$
D. $H_3PO_4(aq)$

25. When used to describe a property of acids, the term "strong" means that the acid

A. is caustic
B. has a high pH
C. is concentrated
D. dissociates completely

26. The pH of a 0.001 mol/L LiOH solution is

A. 3
B. 7
C. 10
D. 11

27. As a solution becomes more basic, the

A. $[H_3O^+(aq)]$ decreases and the pH increases
B. $[H_3O^+(aq)]$ decreases and the pH decreases
C. $[H_3O^+(aq)]$ increases and the pH increases
D. $[H_3O^+(aq)]$ increases and the pH decreases

28. If the pH of a solution is 8.0, the

A. $[H_3O^+(aq)]$ is 8.0 times as great as the $[OH^-(aq)]$
B. $[OH^-(aq)]$ is greater than 1.0×10^{-7} mol/L
C. $[OH^-(aq)]$ is 1.0×10^{-8} mol/L
D. $[H_3O^+(aq)]$ is 8.0 mol/L

29. When the $[OH^-_{(aq)}]$ of a solution is changed from 10^{-1} mol/L to 10^{-3} mol/L, the indicator

A. methyl orange will remain red
B. phenolphthalein will remain colorless
C. orange IV will change from red to yellow
D. indigo carmine will change from yellow to blue

Use the following information to answer question 30.

Various indicators are added one at a time to a solution that has been divided equally among five test tubes.

TEST TUBE	INDICATOR ADDED	COLOR OF SOLUTION
1	orange IV	yellow
2	methyl orange	yellow
3	bromocresol green	blue
4	methyl red	orange
5	bromothymol blue	yellow

30. The pH range of the solution is

A. 3.0 to 4.0
B. 4.0 to 5.0
C. 5.0 to 6.0
D. 6.0 to 7.0

---

31. If the $[OH^-_{(aq)}]$ of a solution is 1.43×10^{-4} mol/L, the $[H_3O^+_{(aq)}]$ is

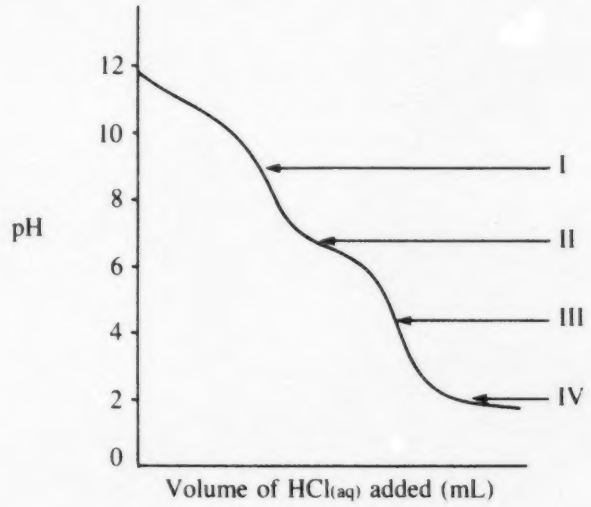
A. 1.43×10^{-4} mol/L
B. 2.43×10^{-10} mol/L
C. 6.99×10^{-11} mol/L
D. 1.00×10^{-14} mol/L

32. At a given temperature, 20% of 0.40 mol/L $CH_3COOH_{(aq)}$ dissociates. The resulting $[H_3O^+_{(aq)}]$ is

A. 4.0×10^{-2} mol/L
B. 8.0×10^{-2} mol/L
C. 4.0×10^{-1} mol/L
D. 8.0×10^{-1} mol/L

Use the following information to answer questions 33 and 34.

Hydrochloric acid is continuously added to a sodium carbonate solution that contains the indicators phenolphthalein and bromocresol green. A pH meter was used to obtain the data for the titration curve shown below.



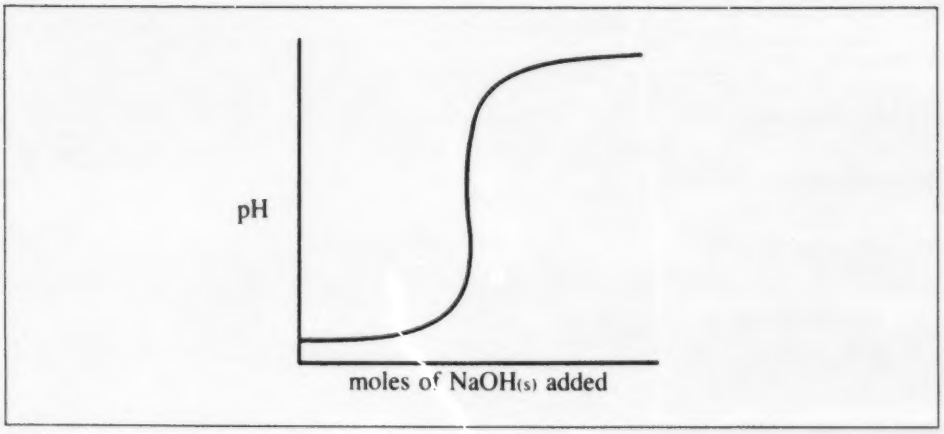
33. The Brønsted-Lowry base reacting at region II would be

A. $CO_3^{2-}{}_{(aq)}$
B. $HCO_3^-{}_{(aq)}$
C. $H_2CO_{3(aq)}$
D. $Cl^-{}_{(aq)}$

34. Bromocresol green indicator would indicate an endpoint at

A. I
B. II
C. III
D. IV

Use the following information to answer question 35.



35. As the titration shown by the graph progresses, the

A. $[OH^-_{(aq)}]$ decreases
B. $[H_3O^+_{(aq)}]$ increases
C. $[H_3O^+_{(aq)}]$ decreases
D. $[OH^-_{(aq)}]$ remains constant

---

36. The volume of 0.50 mol/L $HClO_{4(aq)}$ required to neutralize 200.0 mL of 0.60 mol/L $Ba(OH)_{2(aq)}$ is

A. 120 mL
B. 200 mL
C. 240 mL
D. 480 mL

37. A 40.0 mL solution of 5.0×10^{-4} mol/L HCl is added to 100.0 mL of 1.3×10^{-4} mol/L NaOH. The resulting pH is

A. 7.0
B. 4.3
C. 3.8
D. 3.3

38. An example of an oxidation half-reaction is

A. $Na_{(s)} \longrightarrow Na^+_{(aq)} + e^-$

B. $Cl_{2(g)} + 2e^- \longrightarrow 2Cl^-_{(aq)}$

C. $Fe^{3+}_{(aq)} + e^- \longrightarrow Fe^{2+}_{(aq)}$

D. $MnO^-_{4(aq)} + 8H^+_{(aq)} + 5e^- \longrightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$

Use the following information to answer question 39.

A strip of metal X is placed in a test tube containing a green solution of Z^+. After a short time, the green color disappears and a solid forms on the bottom of the tube.

39. Which statement is the best interpretation of the observations?

A. X is reduced.
B. Z^+ is reduced.
C. Z^+ is the reducing agent.
D. X is the oxidizing agent.

---

40. In the reaction $X + T^{3+} \longrightarrow X^+ + T^{2+}$, the reducing agent is

A. X
B. X^+
C. T^{3+}
D. T^{2+}

41. The balanced net ionic equation for the reaction between $Pb_{(s)}$ and $Ag^+_{(aq)}$ is

A. $Pb_{(s)} + 2Ag^+_{(aq)} + 2e^- \longrightarrow 2PbAg_{(s)}$
B. $Pb_{(s)} + Ag^+_{(aq)} \longrightarrow Pb^{2+}_{(aq)} + Ag_{(s)}$
C. $Pb_{(s)} + 2Ag^+_{(aq)} \longrightarrow Pb^{2+}_{(aq)} + 2Ag_{(s)}$
D. $Pb_{(s)} + 2Ag^+_{(aq)} + 2e^- \longrightarrow Pb^{2+}_{(aq)} + 2Ag_{(s)} + 2e^-$

42. The expression that illustrates an electron loss is

A. $H \longrightarrow H^+$
B. $Cl \longrightarrow Cl^-$
C. $Fe^{3+} \longrightarrow Fe^{2+}$
D. $ClO_3^- \longrightarrow ClO_2^-$

43. Consider the equation $3Hg_{(g)} + 2AuCl_4^-{}_{(aq)} \longrightarrow 3Hg^{2+}_{(aq)} + 2Au_{(s)} + 8Cl^-_{(aq)}$. The CHANGE in the oxidation number of Au in this reaction is

A. 0
B. 1
C. 3
D. 6

Use the following information to answer question 44.

The unbalanced equation for the reaction of Br^- with MnO_4^- is
$Br^-_{(aq)} + MnO^-_{4(aq)} + H^+_{(aq)} \longrightarrow Br_{2(l)} + Mn^{2+}_{(aq)} + H_2O_{(l)}$.

44. When the equation is balanced using the smallest possible whole numbers, the coefficient of $MnO^-_{4(aq)}$ is

A. 1
B. 2
C. 4
D. 5

---

45. The number of moles of electrons needed to convert 4.0 g of $Ca^{2+}_{(aq)}$ to calcium metal is

A. 0.10 mol
B. 0.20 mol
C. 1.0 mol
D. 2.0 mol

46. When 8.1 g of $Al_{(s)}$ react with excess $HCl_{(aq)}$, the mass of $H_{2(g)}$ formed is

A. 0.15 g
B. 0.30 g
C. 0.45 g
D. 0.91 g

47. The half-cell reaction that is used as a standard for the comparison of reduction potentials is

A. $Li^+_{(aq)} + e^- \longrightarrow Li_{(s)}$

B. $F_{2(g)} + 2e^- \longrightarrow 2F^-_{(aq)}$

C. $2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$

D. $O_{2(g)} + 4H^+_{(aq)} + 4e^- \longrightarrow 2H_2O_{(l)}$

48. If $Br_{2(l)} + 2e^- \longrightarrow 2Br^-_{(aq)}$ is assigned a potential of 0.00 V, then the potential for $K^+_{(aq)} + e^- \longrightarrow K_{(s)}$ is

A. −3.99 V
B. −2.92 V
C. −1.85 V
D. −1.07 V

49. $Ag^{+}_{(aq)}$ can be reduced by

A. $Au_{(s)}$

B. $F^{-}_{(aq)}$

C. $Cl_{2(g)}$

D. $Fe^{2+}_{(aq)}$

Use the following information to answer question 50.

Four elements, Z, T, X, and R, form diatomic molecules and negative ions. The following observations are made:

$$Z_2 + 2X^- \longrightarrow 2Z^- + X_2$$
$$T_2 + 2R^- \longrightarrow \text{no reaction}$$
$$X_2 + 2R^- \longrightarrow 2X^- + R_2$$

50. When the elements are arranged in order from most reactive to least reactive, the list is

A. Z_2, X_2, R_2, T_2
B. T_2, R_2, X_2, Z_2
C. T_2, R_2, Z_2, X_2
D. T_2, X_2, R_2, Z_2

---

51. The standard potential of a zinc-acidified dichromate electrochemical cell is

A. +0.35 V
B. +0.57 V
C. +1.17 V
D. +2.09 V

52. A zinc anode and an unknown cathode are connected to form a cell with a net potential of 1.59 V. The electrode potential for the reduction half-reaction is

A. −1.59 V
B. −0.76 V
C. +0.83 V
D. +2.35 V

53. Which of the following reactions would occur spontaneously?

A. $Fe_{(s)} + 2Cl^-_{(aq)} \longrightarrow Fe^{2+}_{(aq)} + Cl_{2(g)}$

B. $Cu^{2+}_{(aq)} + 2Ag_{(s)} \longrightarrow Cu_{(s)} + 2Ag^+_{(aq)}$

C. $Cu^{2+}_{(aq)} + Sn^{2+}_{(aq)} \longrightarrow Cu_{(s)} + Sn^{4+}_{(aq)}$

D. $MnO^-_{4(aq)} + 8H^+_{(aq)} + Pb^{2+}_{(aq)} \longrightarrow Pb_{(s)} + Mn^{2+}_{(aq)} + 4H_2O_{(l)}$

54. If, during the electrolysis of molten aluminum oxide, $Al_2O_{3(l)}$, a current of 2.0 A flows for 50 min, the number of moles of $Al_{(s)}$ that will be deposited is

A. 6.2×10^{-2} mol
B. 2.1×10^{-2} mol
C. 1.0×10^{-3} mol
D. 3.5×10^{-4} mol

55. A process that involves a change from chemical energy into electrical energy is the

A. discharging of a lead storage battery
B. recharging of an Ni-Cd cell
C. electroplating of silver
D. electrolysis of water

56. During the electroplating of silver spoons, silver is deposited by

A. oxidizing silver ions at the cathode
B. reducing silver ions at the cathode
C. oxidizing silver ions at the anode
D. reducing silver ions at the anode

YOU HAVE NOW COMPLETED THE MULTIPLE-CHOICE SECTION OF THE EXAMINATION. PLEASE PROCEED TO THE NEXT PAGE AND ANSWER THE WRITTEN-RESPONSE QUESTIONS IN PART B.

PART B

INSTRUCTIONS

Please write your answers in the examination booklet as neatly as possible.

Marks will be awarded for pertinent explanations, calculations, formulas, and answers. Answers must be given to the appropriate number of significant digits.

NOTE: The perforated pages at the back of this booklet may be torn out and used for your rough work.

TOTAL MARKS: 14

START PART B IMMEDIATELY

(5 marks) 1. A student is required to determine the heat of reaction for $Ca_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow CaO_{(s)}$ using the following reactions and the data collected.

Reaction I $Ca_{(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_{2(g)}$ $\Delta H = ?$

Reaction II $CaO_{(s)} + 2HCl_{(aq)} \longrightarrow CaCl_{2(aq)} + H_2O_{(l)}$ $\Delta H = ?$

Reaction III $H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)}$ $\Delta H = -285.9$ kJ

Reaction	Mass	Volume 1.0 mol/L $HCl_{(aq)}$	Initial Temperature	Final Temperature
I	0.50 g $Ca_{(s)}$	1.00×10^2 mL	22.3°C	35.9°C
II	1.50 g $CaO_{(s)}$	1.00×10^2 mL	22.0°C	29.1°C

Assume specific heat and density of $HCl_{(aq)}$ are the same values as for water.

a. Determine the ΔH value per mole of $Ca_{(s)}$ in Reaction I.

b. Determine the ΔH value per mole of $CaO_{(s)}$ in Reaction II.

c. Using reactions I, II, and III, determine the ΔH value for the combustion of $Ca_{(s)}$.

(5 marks) 2. a. Write two net ionic equations that correctly illustrate the role of the dihydrogen phosphate ion as an acid and as a base, using nitric acid and the hydrogen carbonate ion. List the conjugate acid-base pairs for each reaction.

Equations:

Equation 1 (using nitric acid)

_____

Equation 2 (using the hydrogen carbonate ion)

_____

Conjugate acid-base pairs:

Equation 1 _____acid_____ – _____base_____

_____ – _____

_____ – _____

Equation 2 _____acid_____ – _____base_____

_____ – _____

_____ – _____

b. Predict whether reactants or products are favored for each equation in part a.

equation 1 _____ favored

equation 2 _____ favored

Use the following information to answer question 3.

You are given unlabelled strips of magnesium, tin, and zinc, as well as the following 1.0 mol/L solutions:

$Ca(NO_3)_{2(aq)}$	$Cu(NO_3)_{2(aq)}$
$Co(NO_3)_{2(aq)}$	$Fe(NO_3)_{2(aq)}$
$Al(NO_3)_{3(aq)}$	$Pb(NO_3)_{2(aq)}$

(4 marks) 3. Describe an experimental procedure using oxidation-reduction reactions that would enable you to identify each metal. Indicate the chemicals that you would use and explain how the results would enable you to identify the metals.

YOU HAVE NOW COMPLETED THE EXAMINATION. IF YOU HAVE TIME, YOU MAY WISH TO GO BACK AND CHECK YOUR ANSWERS.

TEAR-OUT SHEET

(NO MARKS WILL BE GIVEN FOR WORK DONE ON THIS PAGE)

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